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CONTRIBUTION OF MODIS LAND COVER PRODUCT TO THE ANALYSIS OF THE AGRICULTURAL DOMAIN BETWEEN 2001 AND 2011 IN WEST AFRICA

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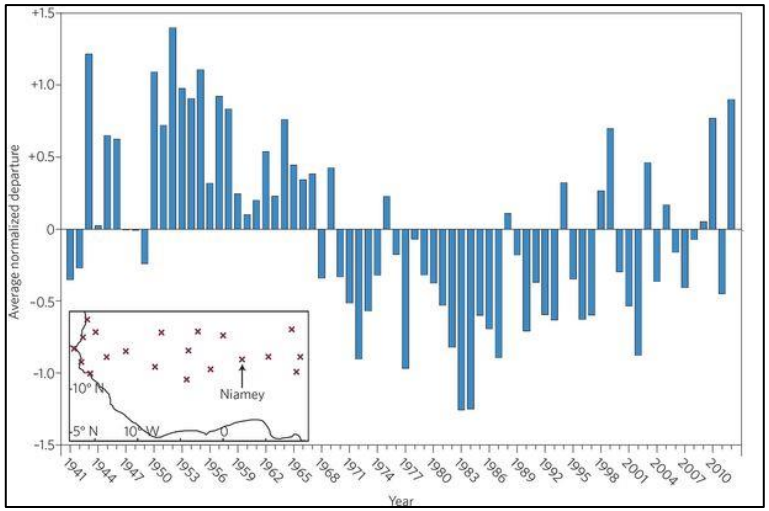
Background of the study

Food security in West Africa

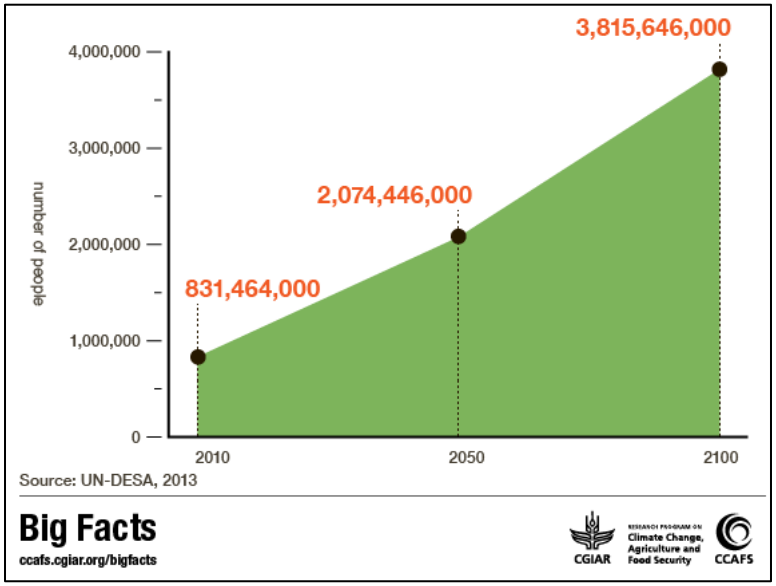
West Africa is characterized by:

A strong climate variability in space and time



Boyd et al., 2013, NCC

High population growth rates



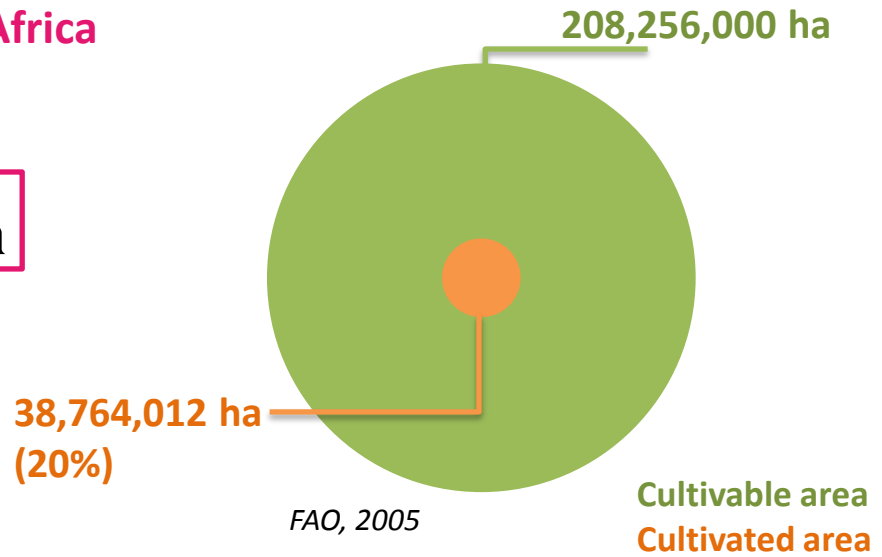
→ Impacts on agricultural production and on food security

Challenge of West Africa : Enhance knowledge on crop production dynamics both at regional and local scale

Background of the study

Crop production and crop area in West Africa

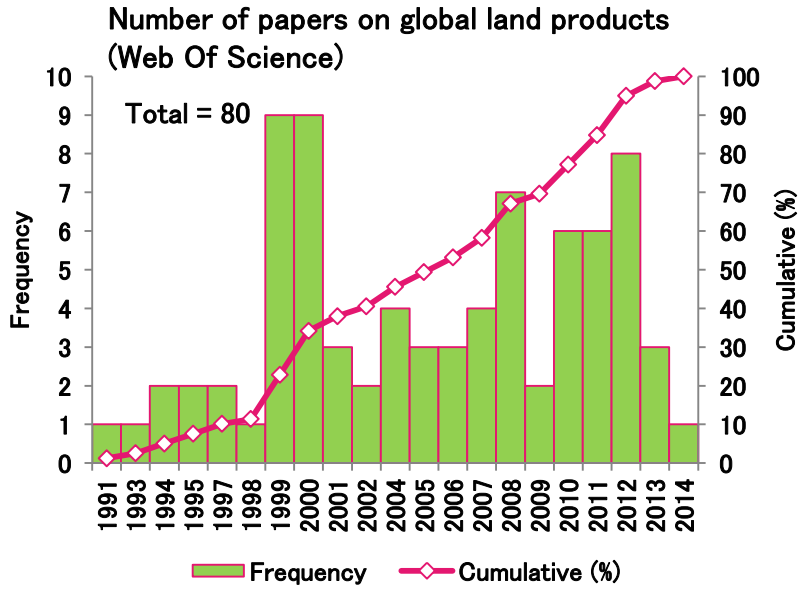
Production = Yield x Area



FAO, 2005

Remote sensing and the monitoring of crop areas

- Global land products: improve our understanding of the extent and distribution of major land cover types at a global scale
- Maps locating the most important cropping areas



Objectives of the study

Question addressed:

What is the reliability of Global Land Cover products for crop areas characterisation and mapping in West Africa?

Case study of the MODIS Land Cover Product v5.1 (MCD12Q1.V51)

Outline:

1. Assessment of cultivated areas
   - Agricultural statistic databases
2. Spatial distribution of cultivated areas At local scale
   - Crop areas classification from high resolution images
3. Examine the spatial distribution of the precision at regional scale

To what extent the MODIS Land Cover Product is able to estimate cultivated areas?

Assessment of the MODIS LCP reliability for crop area estimations

Data

- Agricultural Statistic databases

FAOSTAT - Agricultural Land (2001 – 2011)

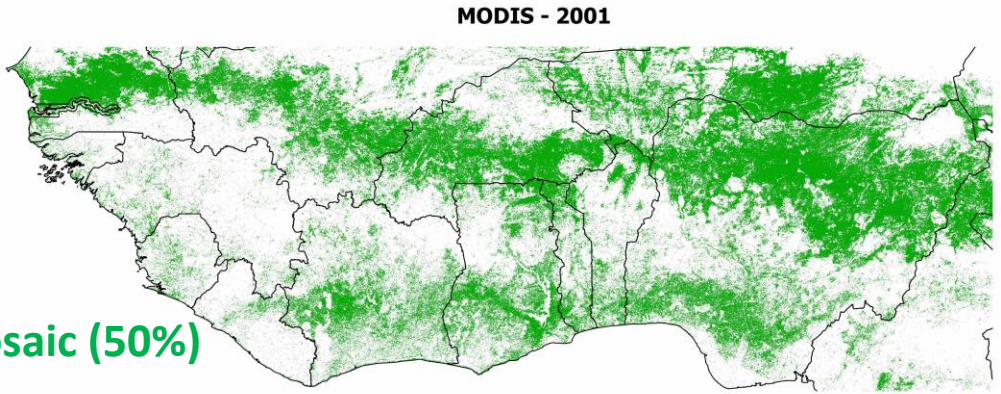
→ Regional & National scales

AGRHYMET - Surfaces harvested for major crops (2001 – 2011)

→ Burkina Faso : Subnational L-1 & Subnational L-2 scales

- MODIS Land Cover Product

→V51 – 500 m - Yearly (2001-2011)



→2 Cropland classes (IGBP):

✓ **Cropland (100%)**

$$Crop_{area} = nbs_{pixels} \times 500^2$$

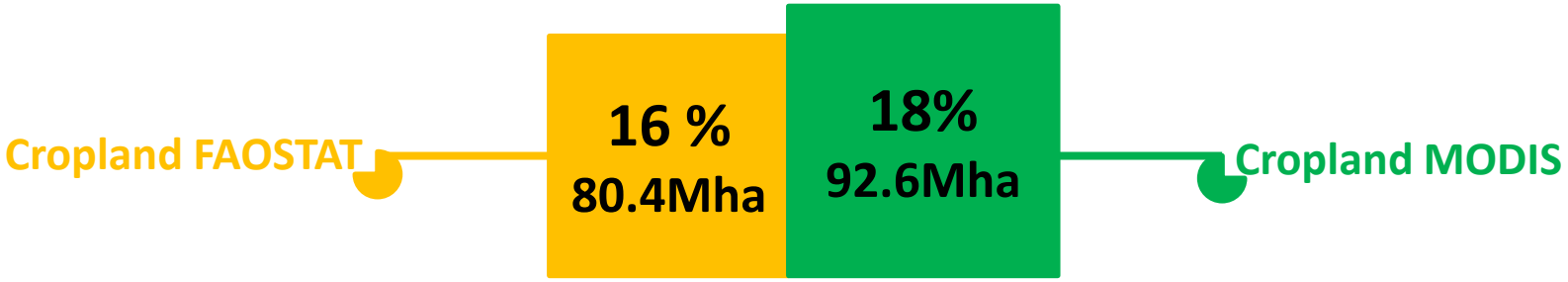
✓ **Cropland/Natural Vegetation Mosaic (50%)**

$$Crop_{area\_mixte} = nbs_{pixels} \times 500^2 \times 0.5$$

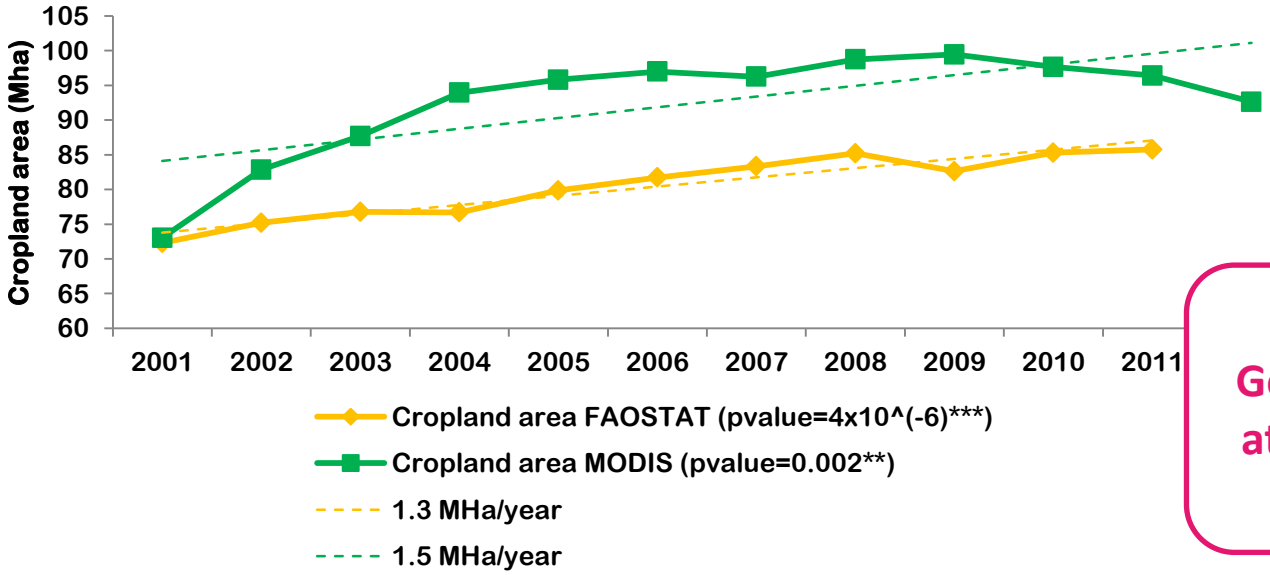
Assessment of the MODIS LCP reliability for crop area estimations

Regional Scale – FAOSTAT/MODIS

Average values between 2001 - 2011



Dynamics between 2001 - 2011

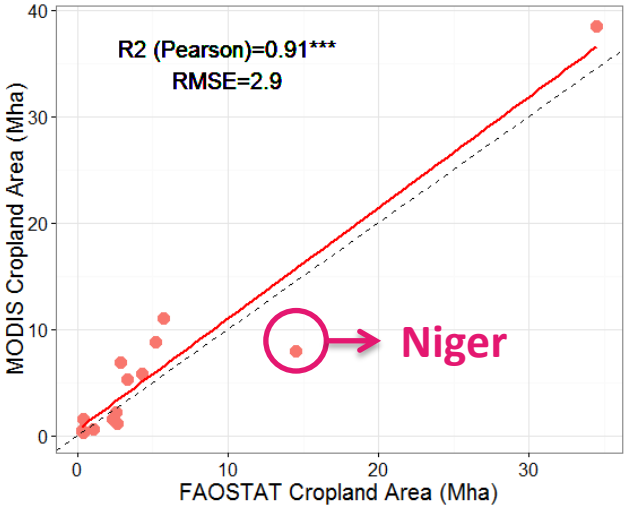


Good estimation at regional scale

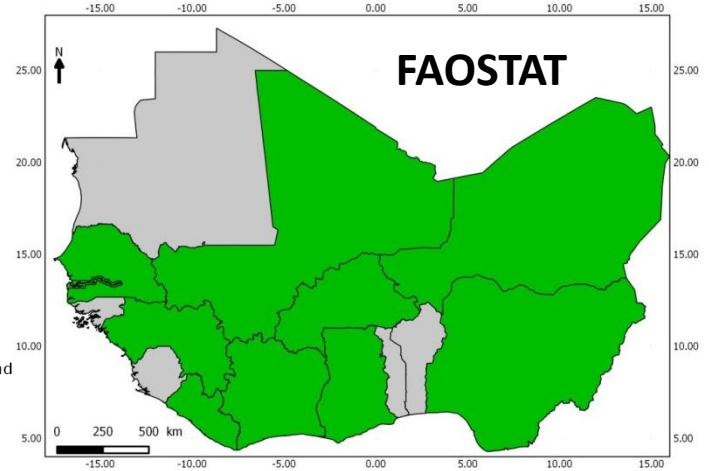
Assessment of the MODIS LCP reliability for crop area estimations

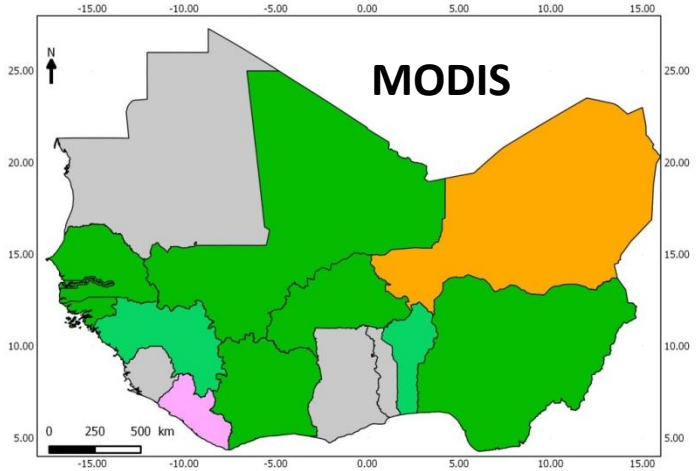
National Scale – FAOSTAT/MODIS

Average values between 2001 - 2011



Dynamics between 2001 - 2011





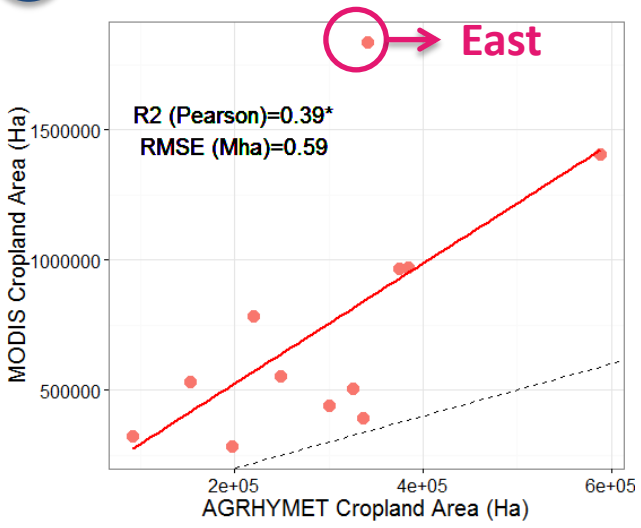
Overall good estimation at national scale

Some discrepancies in terms of dynamics

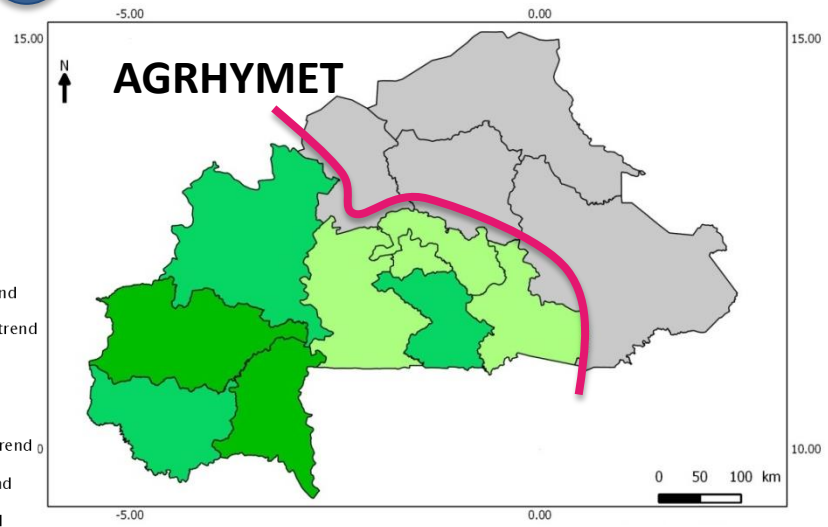
Assessment of the MODIS LCP reliability for crop area estimations

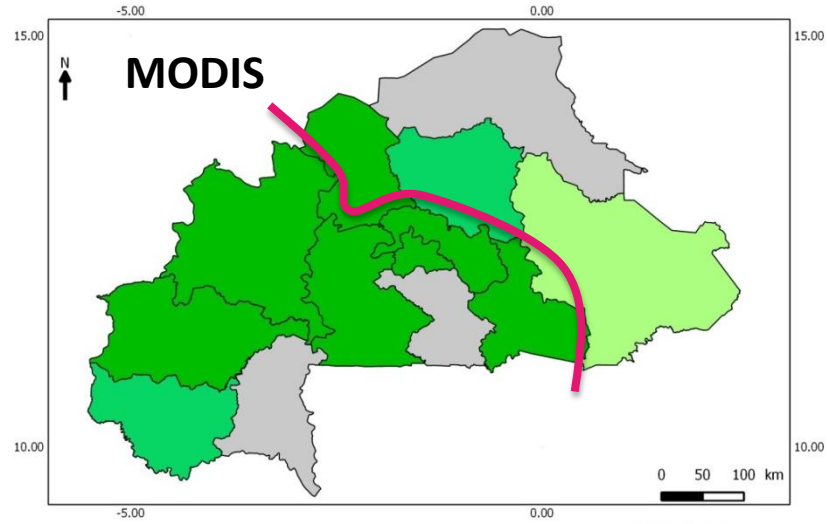
Subnational L-1 Scale (Region)– Burkina Faso – AGRHYMET/MODIS

Average values between 2001 - 2011



Dynamics between 2001 - 2011





Moderate estimation at subnational scale

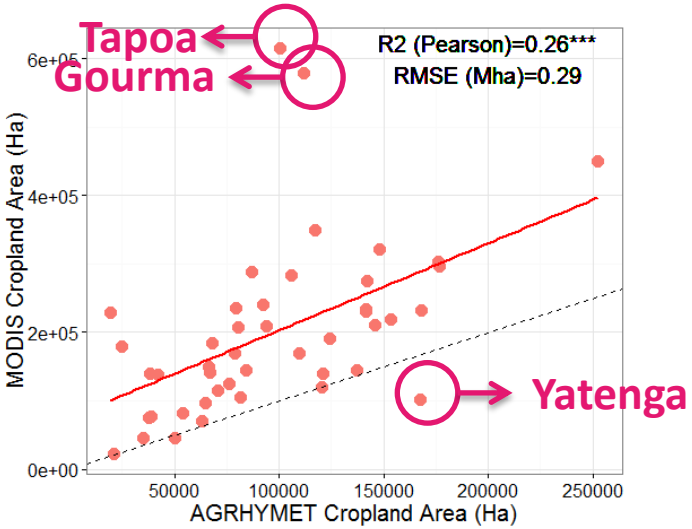
Overestimations by MODIS LCP

Some discrepancies in terms of dynamics - East

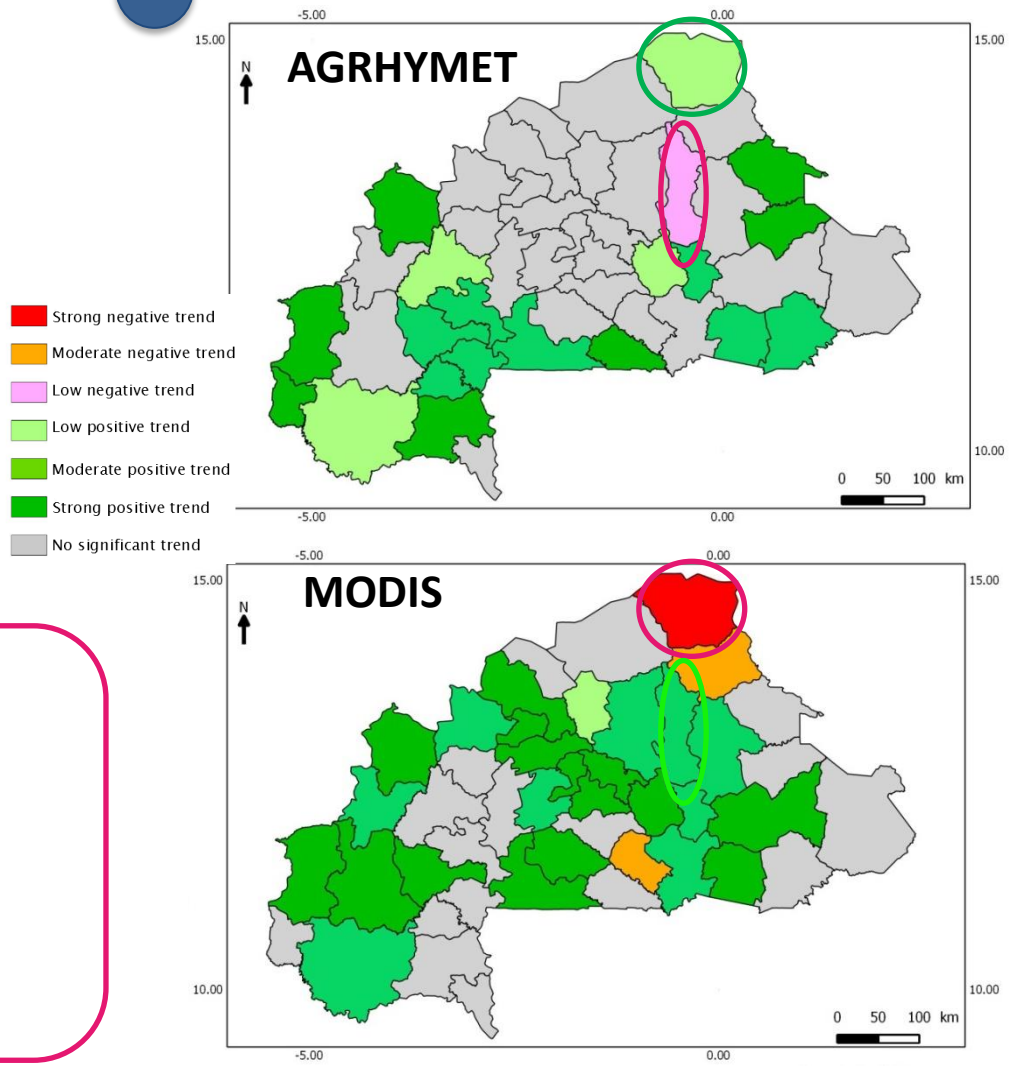
Assessment of the MODIS LCP reliability for crop area estimations

Subnational L-2 Scale (Province) – Burkina Faso – AGRHYMET/MODIS

Average values between 2001 - 2011



Dynamics between 2001 - 2011



- Poor estimation at subnational scale
- Overestimations by MODIS LCP
- Opposite dynamics

What about the MODIS Land Cover Product accuracy concerning the spatial distribution of crop areas?

Assessment of the MODIS LCP accuracy for crop area spatial distribution

Data

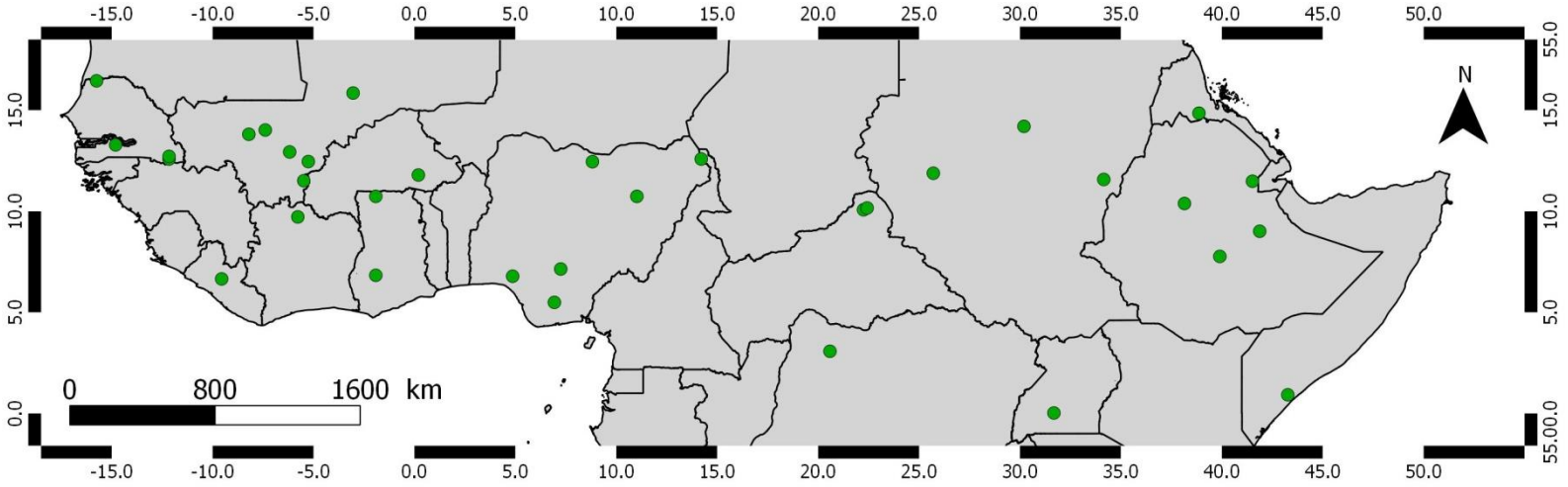
- MODIS Land Cover Product

→ Cropland and mixte cropland classes for 2011

- High resolution classifications of the crop domain

→ 4 classifications from SPOT (2.5m) - Supervised method
2007-Mali *(Vintrou et al., 2012, RSE)*

→ 30 classifications from Google Earth by photo-interpretation
Square of 25km²

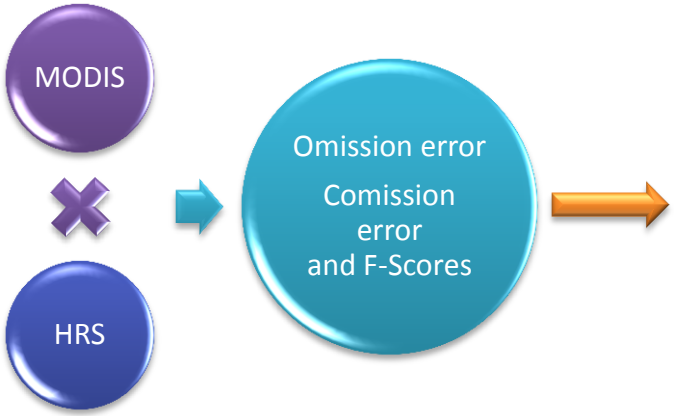


Assessment of the MODIS LCP accuracy for crop area spatial distribution

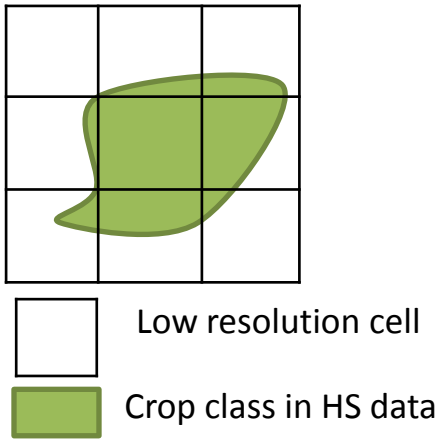
Methods

Error Matrix

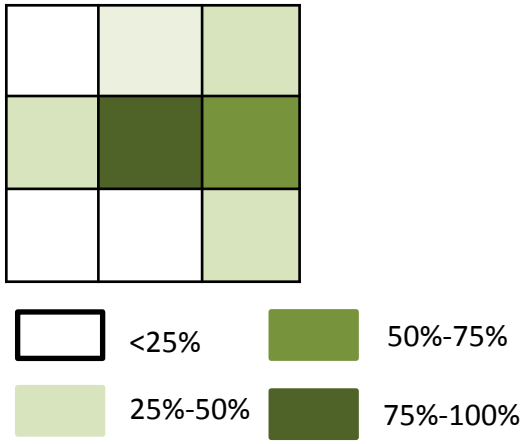
Site size = 5km x 5km
(100 MODIS Pixels)



Pareto Boundary



% of crop class in each low resolution cell



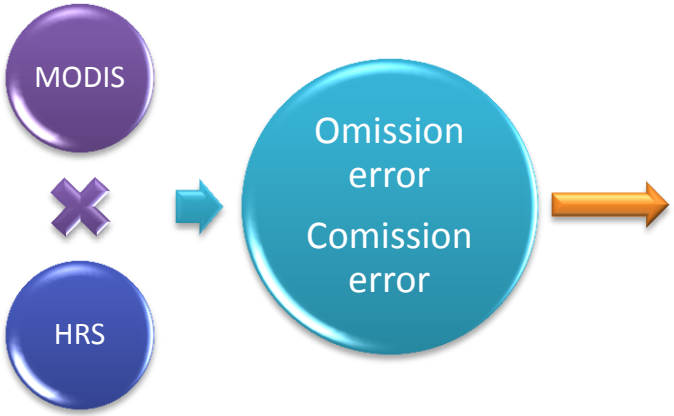
Boschetti et al., 2004 (RSE)

Assessment of the MODIS LCP accuracy for crop area spatial distribution

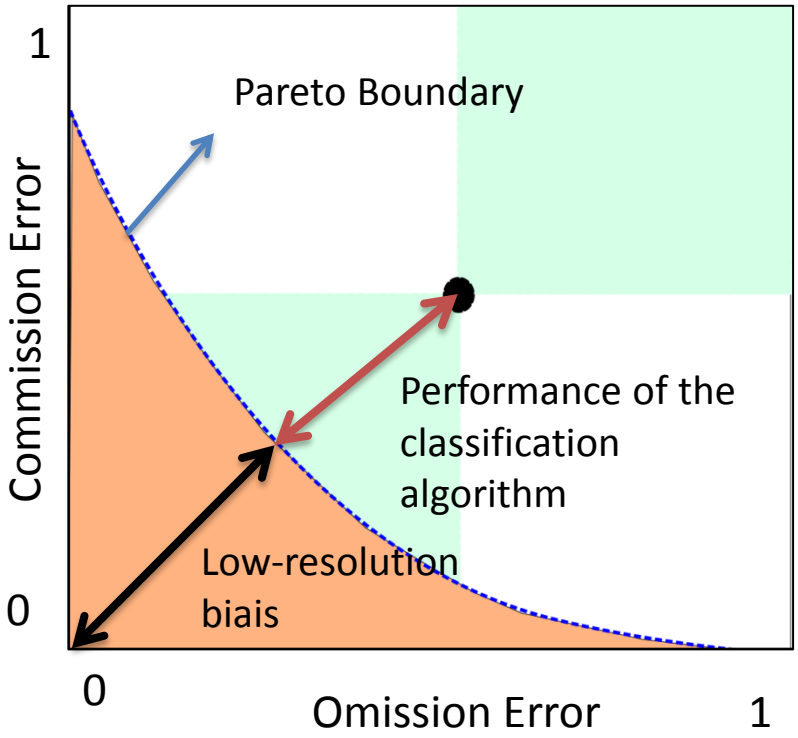
Methods

Confusion Matrix

Site size = 5km x 5km
(100 MODIS Pixels)



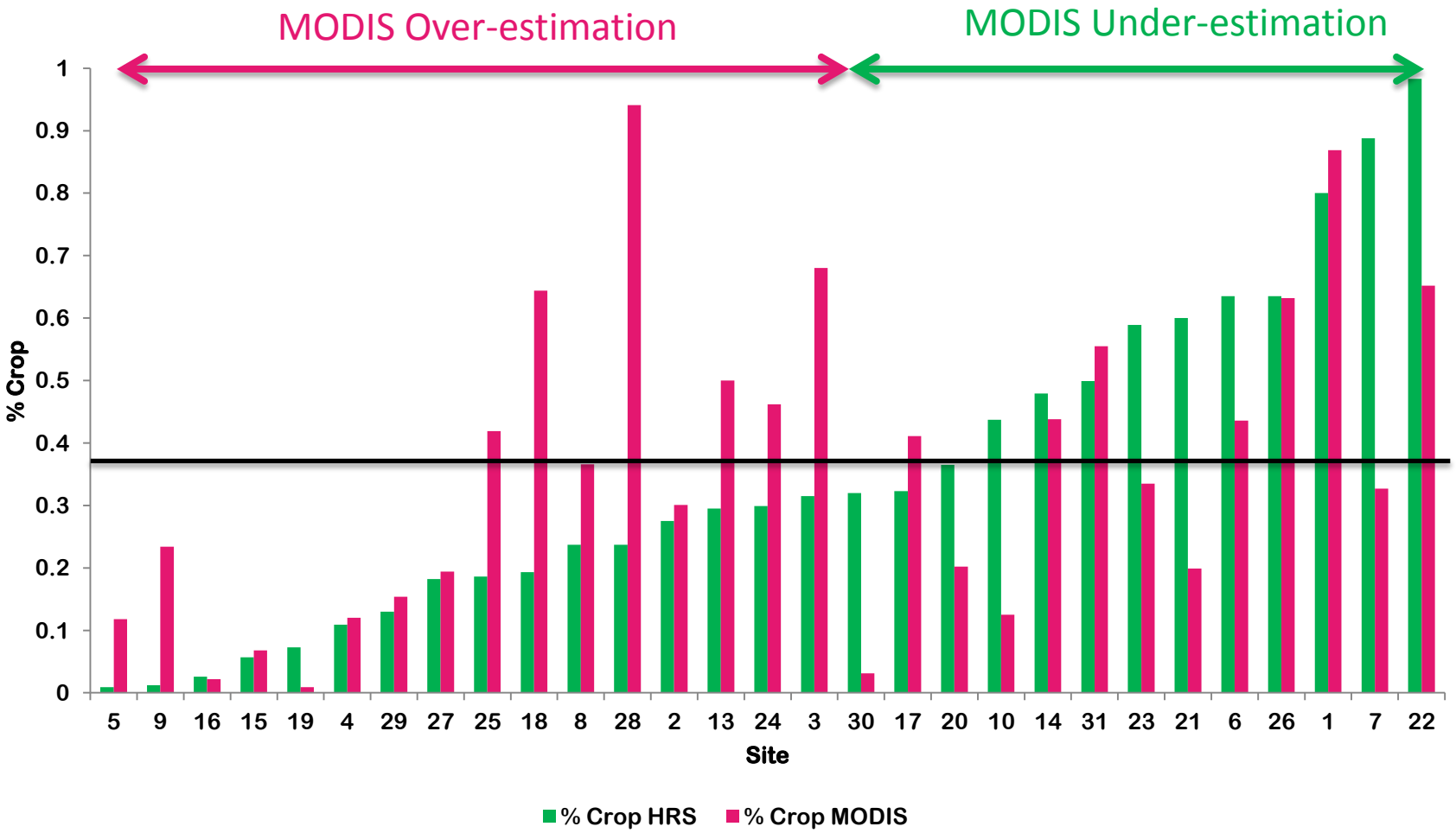
Pareto Boundary



Boschetti et al., 2004 (RSE)

Assessment of the MODIS LCP accuracy for crop area spatial distribution

Crop areas estimation – MODIS vs HRS



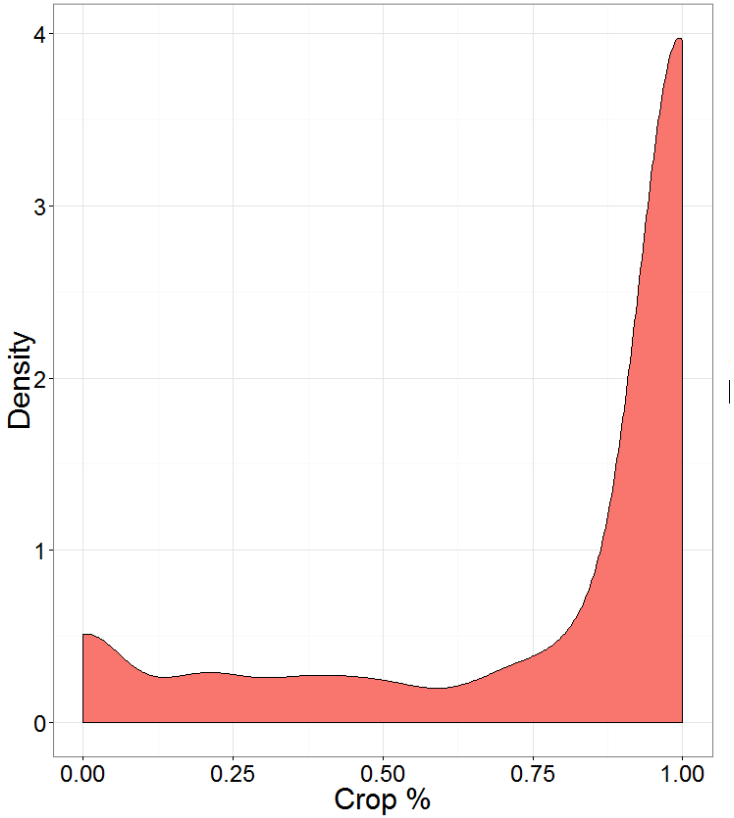
Over-estimation < ~40%< Under-estimation

Assessment of the MODIS LCP accuracy for crop area spatial distribution

Crop areas accuracy – MODIS vs HRS

Zone 1 : North Senegal

% of crop class in each MODIS cell



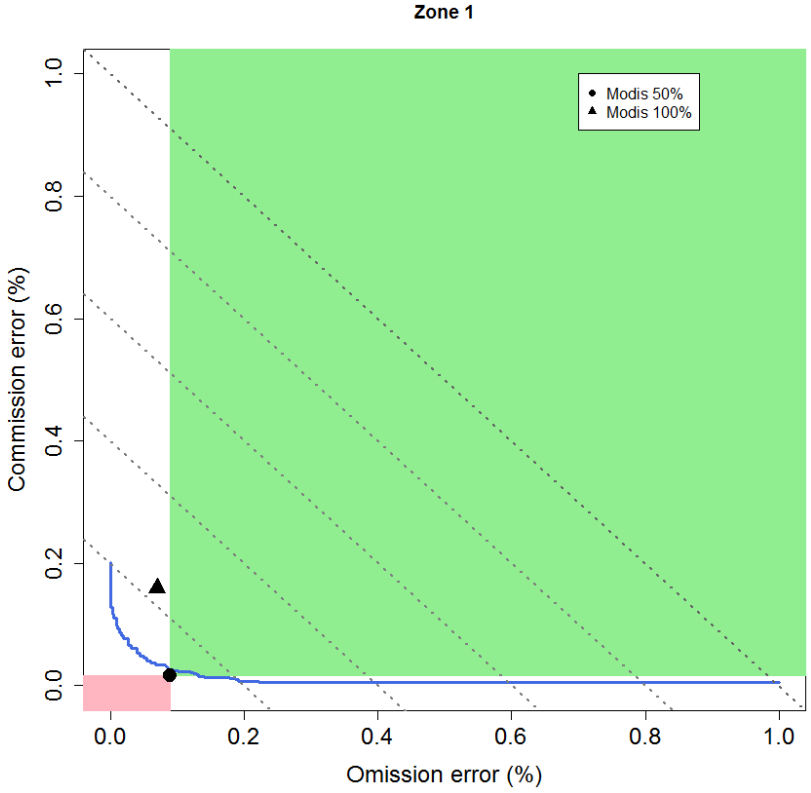
Homogeneous site

Assessment of the MODIS LCP accuracy for crop area spatial distribution

Crop areas accuracy – MODIS vs HRS

Zone 1 : North Senegal

The Pareto Boundary

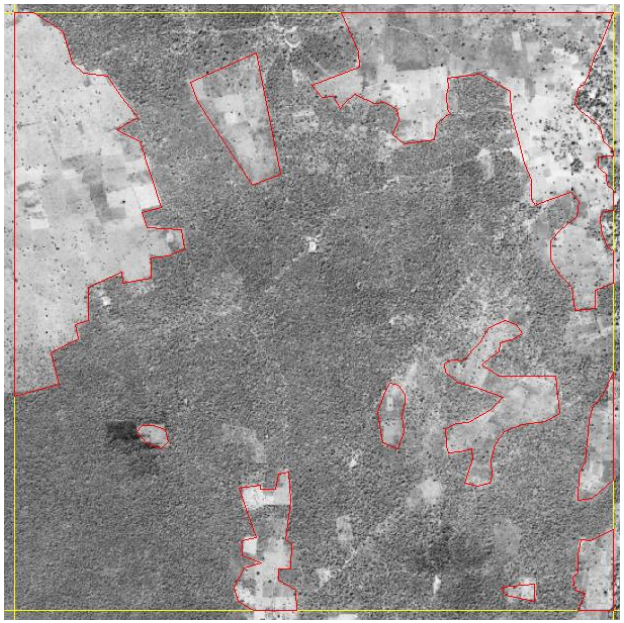


Low unreacheable region
High performance of the MODIS classification

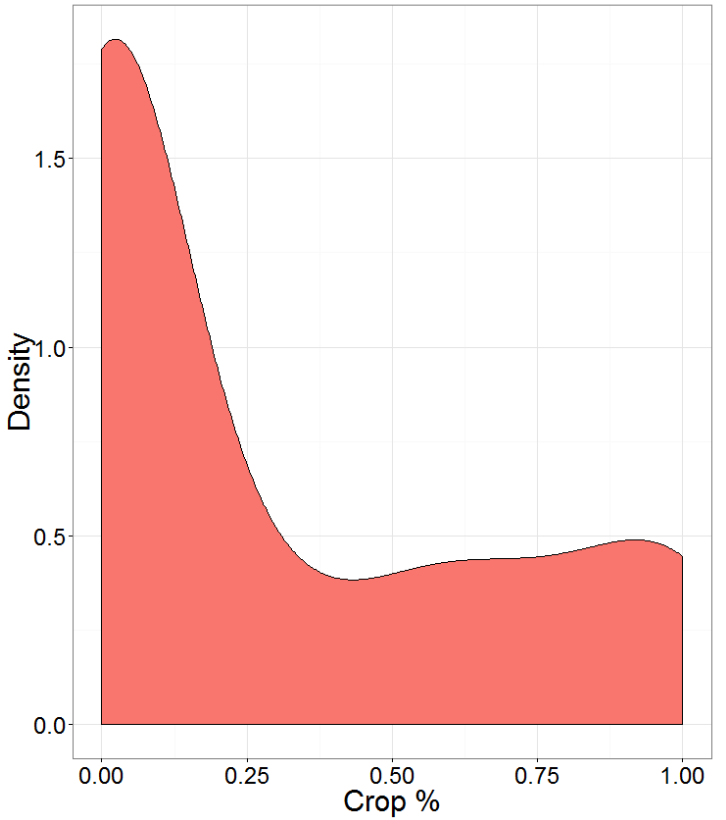
Assessment of the MODIS LCP accuracy for crop area spatial distribution

Crop areas accuracy – MODIS vs HRS

Zone 2 : Gambia



% of crop class in each MODIS cell

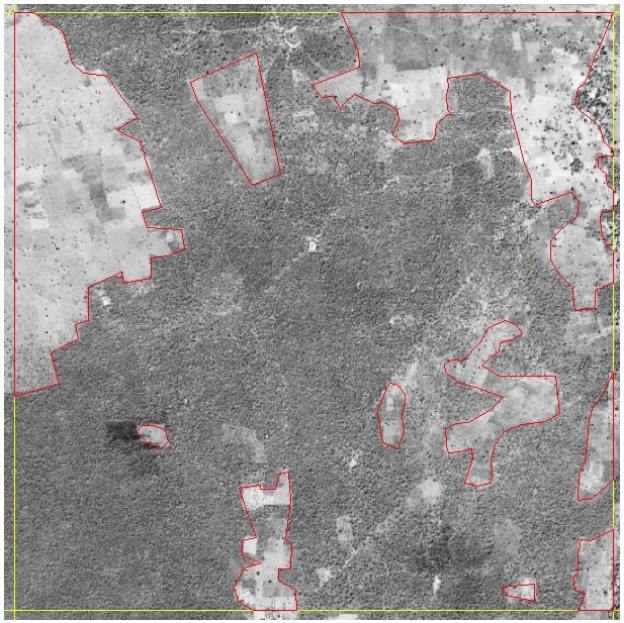


Fragmented site
Large patches of crop

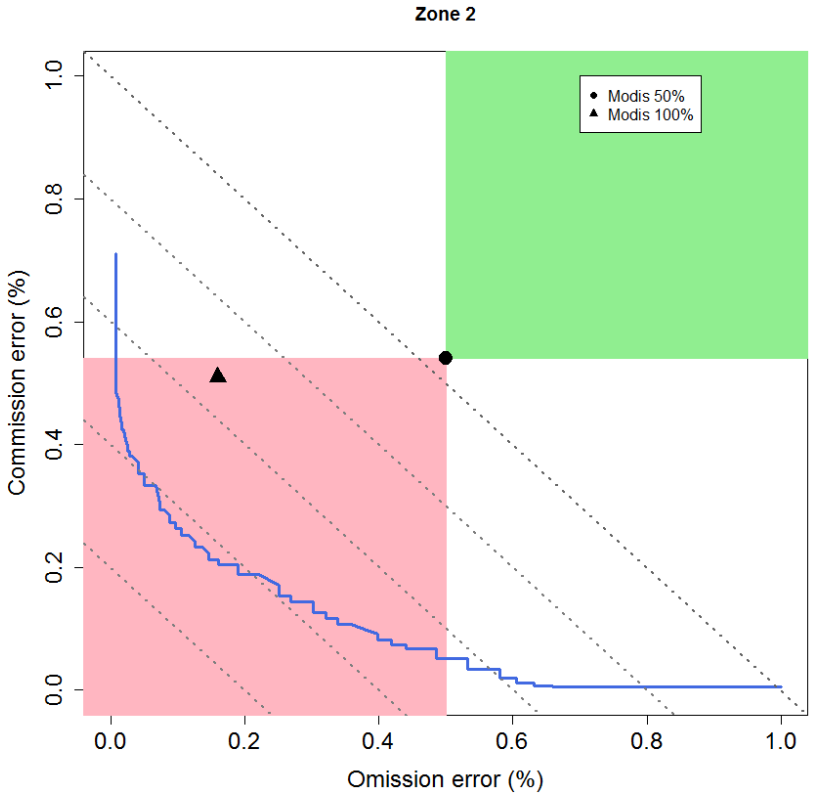
Assessment of the MODIS LCP accuracy for crop area spatial distribution

Crop areas accuracy – MODIS vs HRS

Zone 2 : Gambia



The Pareto Boundary

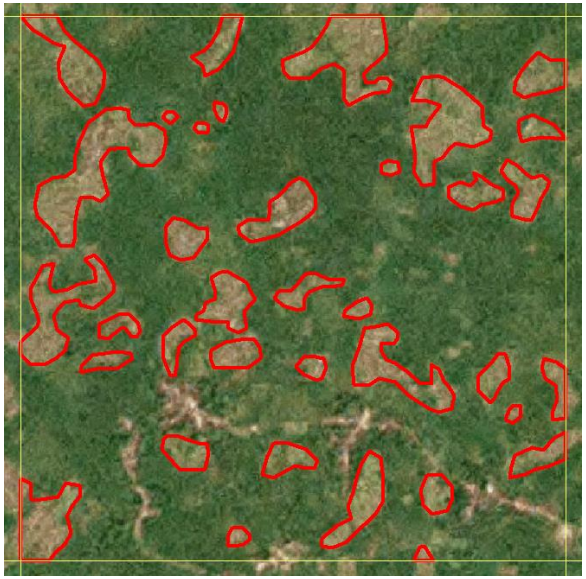


Moderate unreachable region
Moderate performance of the MODIS classification

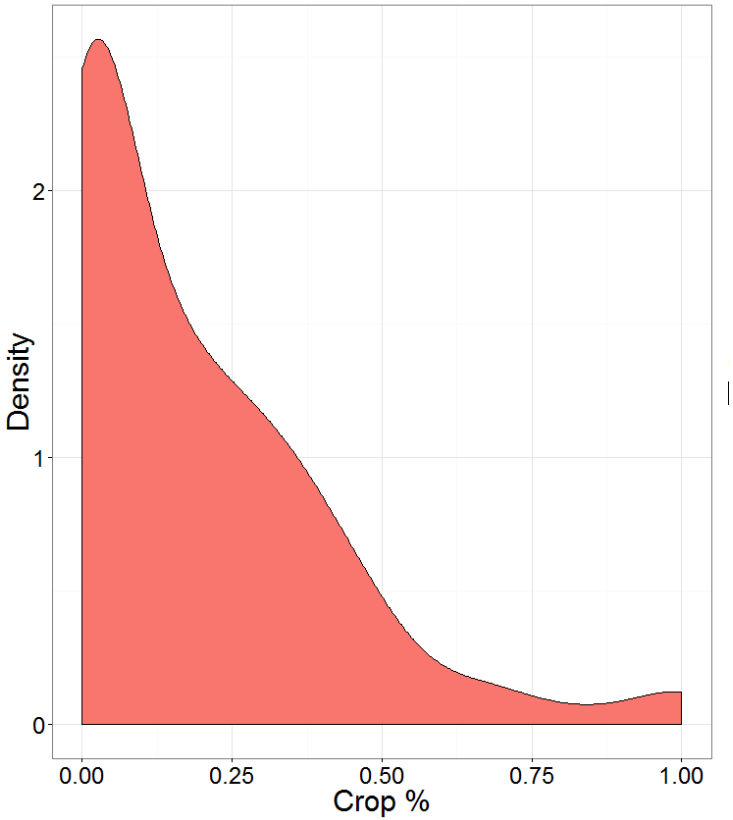
Assessment of the MODIS LCP accuracy for crop area spatial distribution

Crop areas accuracy – MODIS vs HRS

Zone 18 : South Nigeria



% of crop class in each MODIS cell

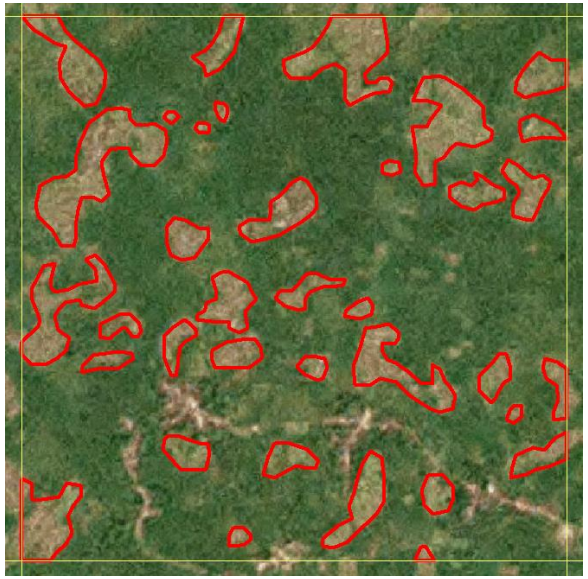


Highly fragmented site
Little patches of crop

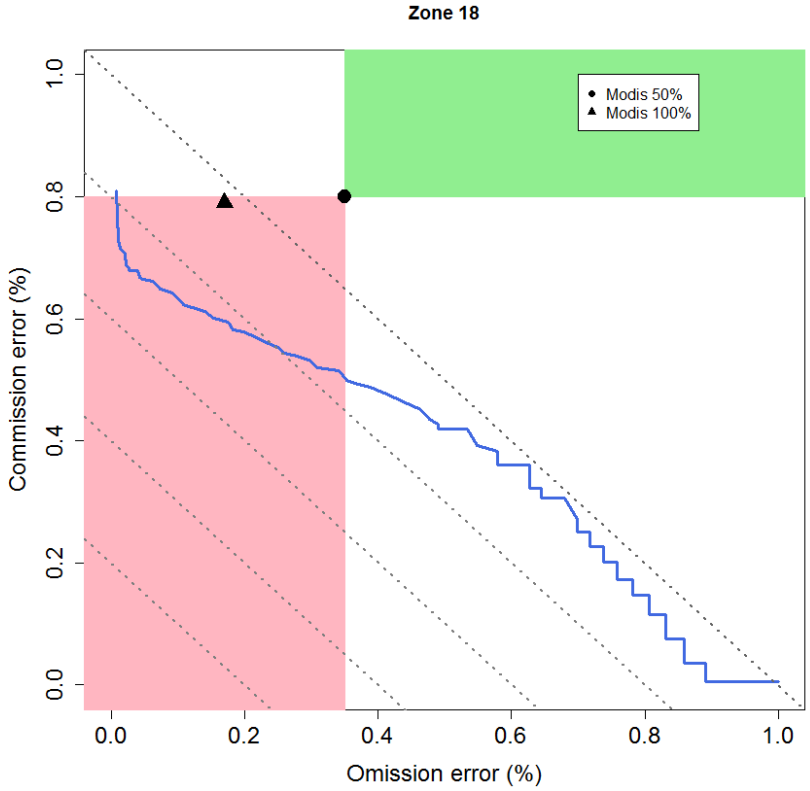
Assessment of the MODIS LCP accuracy for crop area spatial distribution

Crop areas accuracy – MODIS vs HRS

Zone 18 : South Nigeria



The Pareto Boundary



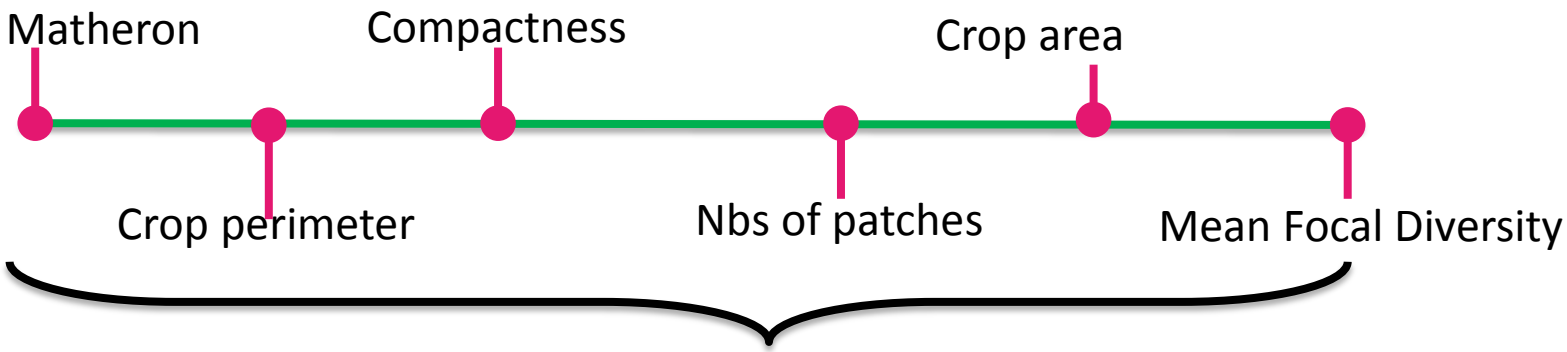
Very High unreachable region
Moderate performance of the MODIS classification

Can we map the crop areas MODIS LCP accuracy considering the landscape spatial heterogeneity?

Map of the MODIS LCP uncertainties for crop areas

Methods

MODIS Indicators of Landscape fragmentation
at regional scale
(grid of 5km x 5km)



ActualAccuracy Indicators
at site scale

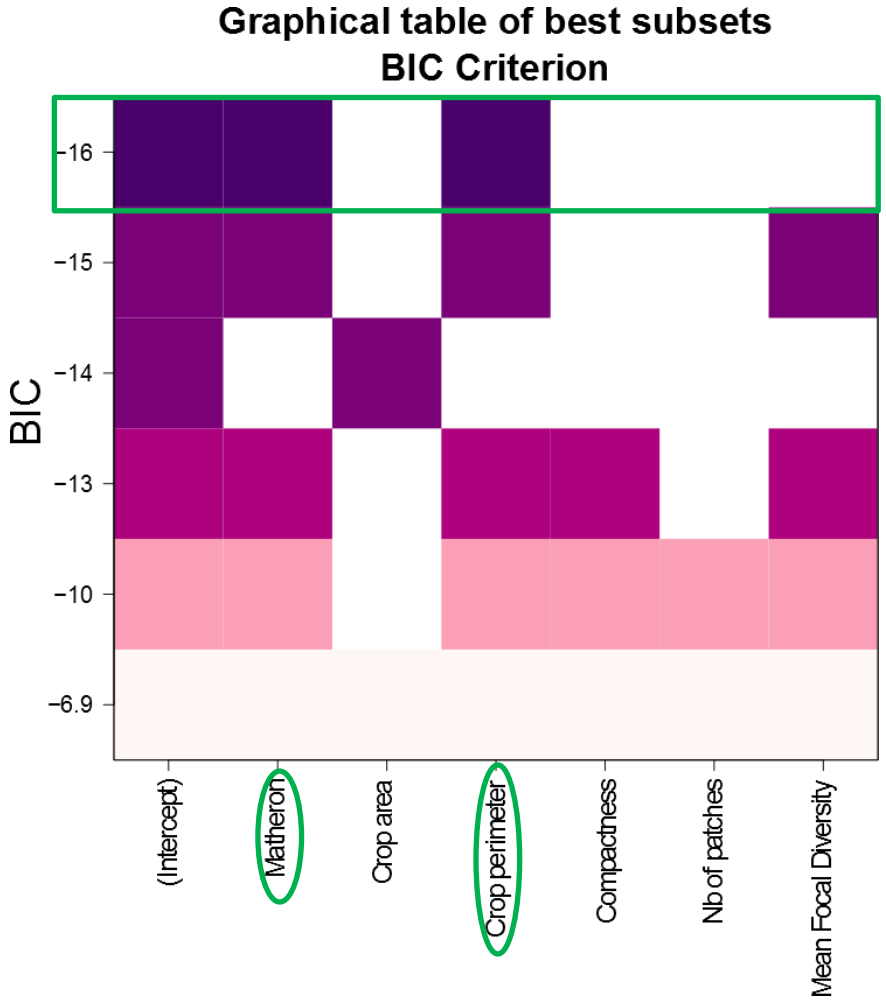
→ Multiple Linear Regression
at the site scale

↓

Estimated Accuracy Indicators
at regional scale

Map of the MODIS LCP uncertainties for crop areas

Variables Selection and Model Fitting

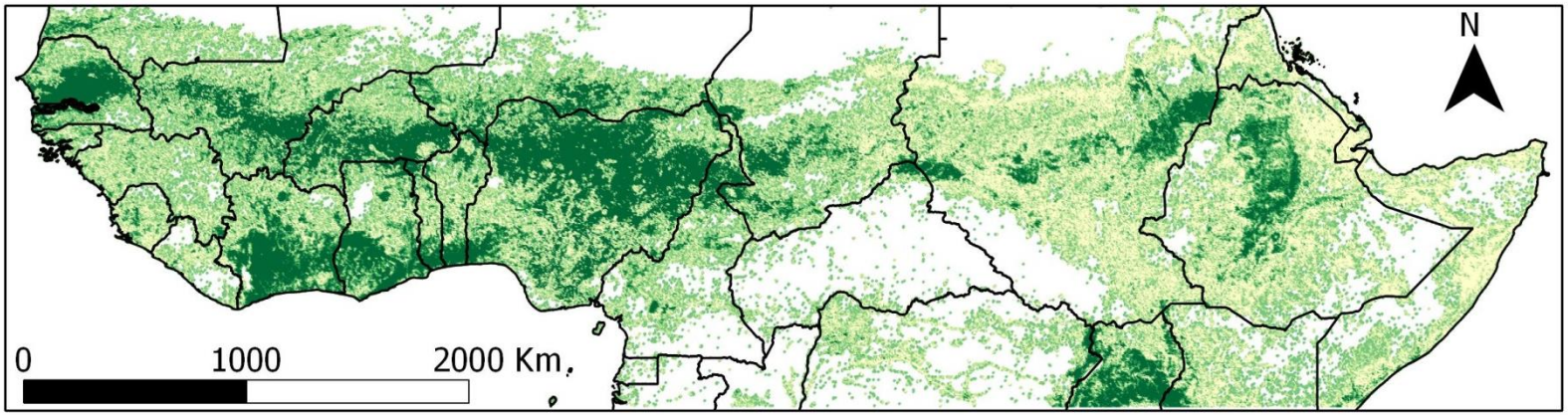


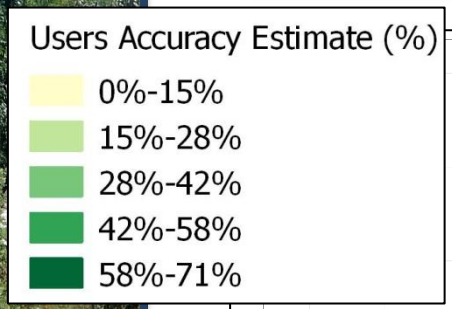
$$Omission = 0.38 + 0.36Matheron - 0.01CropPerimeter$$

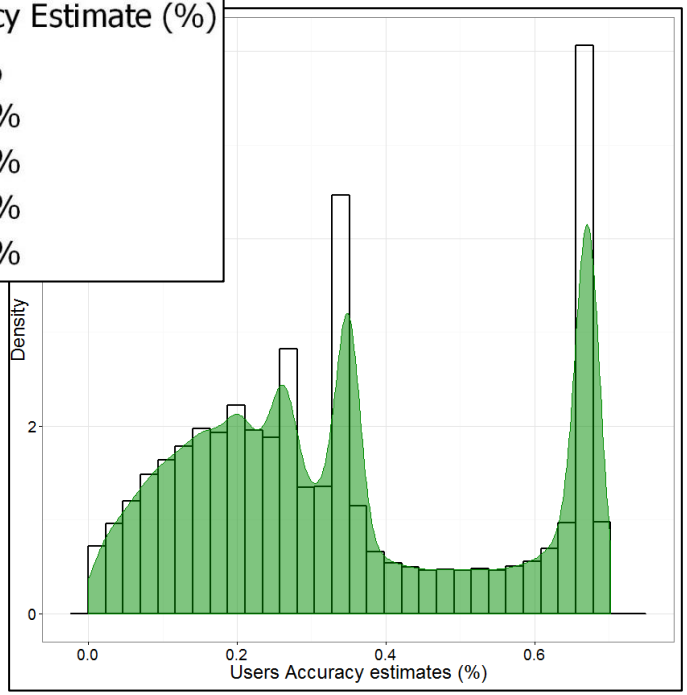
R^2=0.60***
RMSE=0.15%

Map of the MODIS LCP uncertainties for crop areas

Map of the users accuracy estimate





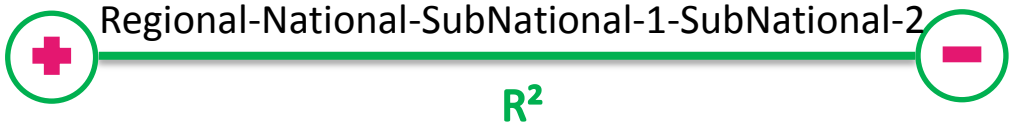


Maximum user accuracy estimate : 70%

Better accuracy estimate in the West

Conclusion

Crop area estimations



- ✓ Definition of Fallows (Statistic)
- ✓ Definition of the Mosaic class (MODIS)
- ✓ Weakness of aggregated statistic data: lack of spatial representativeness

MODIS LCP accuracy for crop area spatial distribution

- ✓ Over-estimation for crop fraction below 40%
- ✓ Fragmented landscape = impact on the low resolution map accuracy
- ✓ Notion of Mixel = Mixed Pixel

Map of the MODIS LCP uncertainties for crop areas

- ✓ Omission error = $F(Matheron, Crop\ Perimeter)$
- ✓ Maximum user accuracy estimate = 70% for crop

→ Increase the number of test sites to improve our results

→ Analyse the spatial distribution of accuracy in accordance with agro-ecological climatic zonations and slopes.

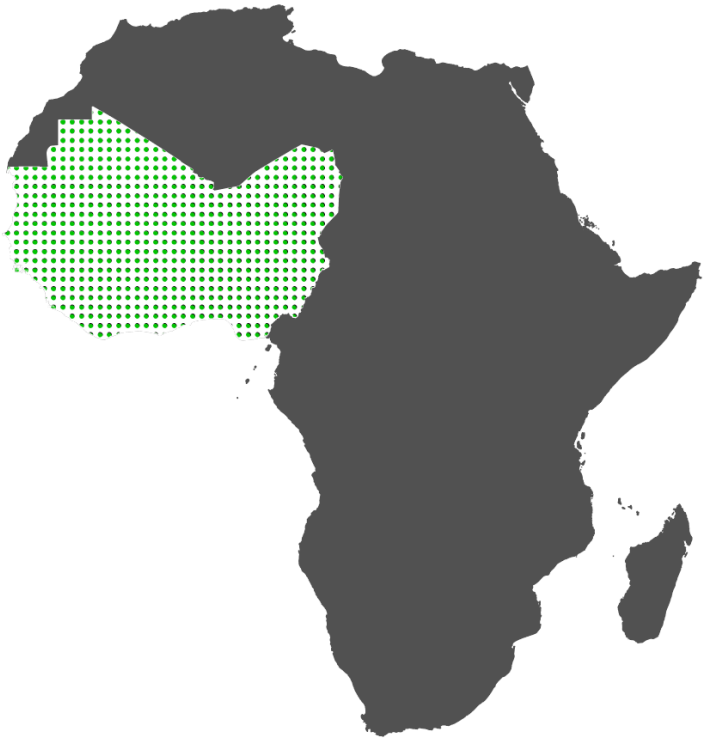
Conclusion

Key ideas

Original approach based on Remote Sensing data and statistic data to assess the reliability of the MODIS LCP for crop areas estimation and localisation in West Africa

An assessment of the Global Land Product accuracy allows to anticipate product limitations for users and leads to appropriate map use

Thank you for listening…



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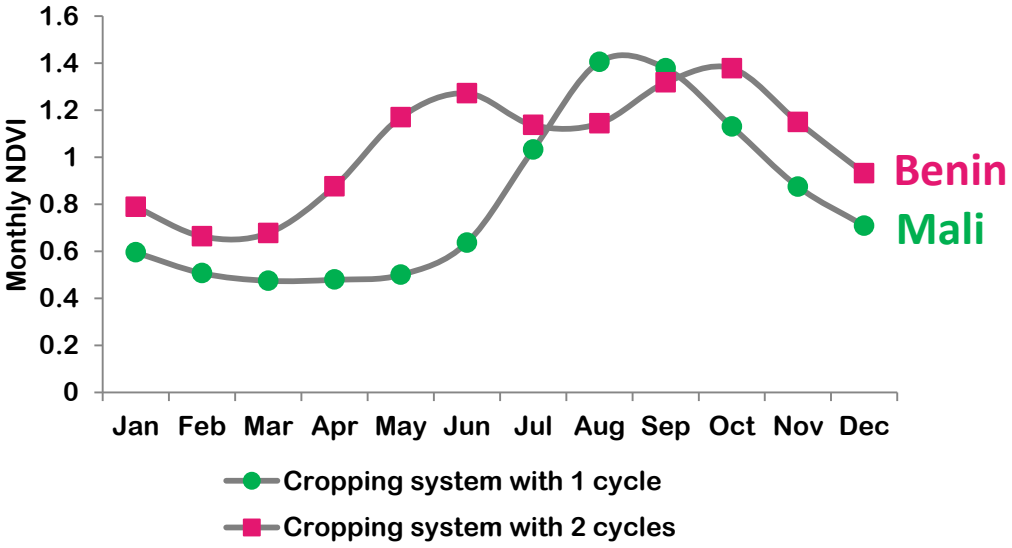
Assessment of the MODIS LCP accuracy for crop area spatial distribution



Map of the MODIS LCP uncertainties for crop areas

Model validation